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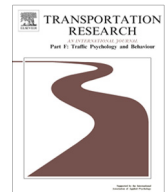
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Differences in cycling performance of Dutch and non-Dutch students in the Netherlands



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ABSTRACT

Thirty-seven young adult participants completed a bicycle ride through the city of Groningen. Behaviour of Dutch and non-Dutch cyclists was compared in three conditions: on a control track (i.e. a one-way bicycle path), on a complex intersection, and on a roundabout. Basic bicycle control of the two groups did not differ, neither did reported invested mental effort. However, non-Dutch participants made more serious errors in the experiment and reported to have had more crashes previous to the experiment. It is concluded that the performance of non-Dutch cyclists who continue cycling upon arrival in a new country, does not differ on the control level, but at the higher manoeuvre level more performance errors were observed in the non-Dutch group.

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1. Introduction

Cycling is being promoted as physically healthy (Oja et al., 2011, Garrard, Rissel, & Bauman, 2012, Rissel, 2015) and environmentally friendly (e.g., Gerike, de Nazelle, Wittwer, & Parkin, 2019). At the same time, cyclists are vulnerable road users and in 2018 as many cyclists (228) as people in passenger cars (233) have died in traffic crashes in The Netherlands (CBS, 2019). This trend has been related to increased unsafety as a result of extended mobility and longer participation of older cyclists in traffic (Martínez-Ruiz et al., 2014). The Netherlands are flat and have a very good bicycle infrastructure (Pucher & Buehler, 2008). As a result, cycling is popular and most Dutch people ride a bicycle. In large cities such as Amsterdam this is not different, and in these cities tourists also hire bicycles to get around. Local people do not always appreciate the cycling behaviour of foreigners, as some are not up to date with the rules while others have difficulty controlling the bicycle and are said to behave in an unsafe way by cycling slowly, stopping suddenly, and swerving out of lane (Nwanazia, 2018). While tourists in general do not stay for longer than a week, universities nowadays attract increasing numbers of international students. In the Netherlands between 2011 and 2018 the number of international students has more than doubled from 26,000 to 56,000 (VSNU, 2019). The city of Groningen (200,000 inhabitants) is no exception to this and hosts both a university (30,000 students in 2018) and a university of applied sciences (more than 20,000 students). In

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2005 there were 669 international students, in 2011 2619, and in 2017 5625 (VSNU, 2019). Many come from close neighbour Germany (2276 in 2018), but more and more also from other countries such as the UK (443 in 2018) and Eastern Europe. While Groningen is a bicycle friendly city and smaller than Amsterdam, the question arises whether the international students that cycle, cycle differently than national students, and perhaps similar to the reported Amsterdam tourists. To the best of our knowledge, this topic has not yet been studied with regard to cycling. Information that is available in the literature about new residents' behaviour in traffic concerns car driving (Romano et al., 2013; Yannis, Golias, & Papadimitriou, 2007).

From driving we know that with regard to non-native driver behaviour, an important distinction must be made between temporary visitors (i.e. tourists) and new residents (immigrants). Tourists, compared to local drivers, are in general at greater risk to get involved in an accident, largely because they have to drive in an unfamiliar environment, in particular in countries where they have to drive on the opposite side of the road to the country they are used to drive (Bellos, Ziakopoulos, & Yannis, 2019; Castillo-Manzano, Castro-Nuño, López-Valpuesta, & Vassallo, 2018; Malhotra, Charlton, Starkey, & Masters, 2018; Wilks, 1999; Wilks, Watson, & Faulks, 1999; Wilks, Watson, & Hansen, 2000). In Japan, Yoh, Okamoto, Inoi, and Doi (2017) found differences on the basis of where foreign drivers came from; North and South Americans tended to speed while Asians violated priority rules more often than national drivers. This resulted in more rear-end crashes for the Americans, and more crashes on intersections for Asians. Immigrants have been stereotyped as worse drivers than native drivers, but if one looks at accident rates in Canada, they actually perform better (Redelmeier, Katz, Lu, & Saposnik, 2011). Also, with regard to violations, Romano et al. (2013) found that recent immigrants in the USA had a lower incidence rate than local drivers, with the exception of red light running. In Europe similar results have been reported by Yannis et al. (2007): tourist non-Greek drivers are at increased risk, but immigrants have a lower risk than tourists, on all types of roads in Greece.

Similar to (incorrect) stereotypes about foreign drivers, there are reports that newly arrived foreign students on a bicycle also can behave unsafely in traffic. Whether this is correct or not, the feeling of safety has an influence on whether or not foreigners start or continue to cycle. According to Billot-Grasset, Amoros, and Hours (2016) this happens in two ways: crash victims cease cycling after having had an accident, or the fear of getting an accident deters potential cyclists. Migrants in the Netherlands tend to cycle less than native Dutch people (Harms, Bertolini, & Te Brömmelstroet, 2014), while it has been shown that many manage to master the skills and use the bicycle as part of daily life, just as locals do, in particular if they take cycling lessons (Van der Kloof, 2015). International students are to a certain extent comparable with immigrants because, in general, they have the intention to stay at least three years to obtain their Bachelor's degree. They are not tourists, but young inhabitants of a city who will become more and more familiar with the environment and are likely to commute, just as many local residents, by bicycle. The question is how they experience cycling in the Netherlands, in particular in the first year, how they perform, and whether they have more (near) crashes. In the present study the focus is not on motivation to cycle, but on actual behaviour and safety of performance.

1.1. Cycling behaviour

Behaviour in traffic is frequently described on three hierarchical levels (Michon, 1985). On the top level, the strategic level, decisions are made with regard to mode of transport and route to take. On the intermediate tactical or manoeuvre level, as the label says, decisions with regard to manoeuvres are made, e.g. whether or not to overtake or give right of way. On the lowest level, the control level, behaviour with regard to vehicle control takes place, e.g., speed control and steering corrections to stay in lane. Automated, predominantly unconscious, behaviour is executed on this level. As described by Rasmussen (1983) and Reason (1990), a large extent of behaviour is automated and shifts from higher (manoeuvre) level to control level. In the beginning, in particular in novel situations or when learning a task, tasks are performed more slowly, consciously, and require more effort. However, after gaining experience, behaviour is increasingly automated and performed without conscious awareness. With regard to cycling it is possible that non-Dutch cyclists need time to adapt to the new environment and in particular when they have not cycled regularly in their country of origin, this may require more effort for basic control skills such as keeping balance (Wierda & Brookhuis, 1991). Cyclists can also compensate for inexperience or difficulties on other levels. For example, cyclists that perform secondary tasks such as operating a mobile phone slow down and keep more distance to the kerb to create more time and allow for steering errors (De Waard, Lewis-Evans, Jelijs, Tucha, & Brookhuis, 2014; Kircher, Ahlstrom, Palmqvist, & Adell, 2015). It is possible that non-Dutch cyclist compensate in a similar way and cycle slower, or have a different lateral displacement and displacement variability. Also, in complex situations they may take more time or have to invest more mental effort to perform as local cyclists do.

In the present study the cycling performance of Dutch and non-Dutch students was compared. The following hypotheses were evaluated:

H0(1). Cycling performance of Dutch and non-Dutch students is similar

H0(2). Non-Dutch students do not have to invest more mental effort in cycling.

Strategic level decisions, such as route choice, are not considered in this study. The focus is on control and manoeuvre level performance.

2. Method

2.1. Participants

Participants were recruited amongst first year University of Groningen Psychology students. These students have to take part in experimental studies as a mandatory part of a first year Psychology undergraduate course. Additionally, two participants voluntarily took part in the field experiment. In total, 37 participants were invited for the experiment (63% female), and were divided into two groups: Dutch or non-Dutch. Sixteen Dutch (10 female) with an average age of 19.6 years (SD 1.6) and 21 non-Dutch (13 female, 57% German) with an average age of 20.5 years (SD 1.8 years) participated. Ethical approval for the study was obtained from the Ethical Committee of the Department of Psychology of the University of Groningen on the condition that participants were required to use a bicycle as a means of transport in everyday life. They were asked to bring their own bicycle for the study to avoid habituation effects to an unfamiliar bicycle. The experiment was carried out outside rush hours between December 12th 2018 and February 22nd 2019 and all participants gave written informed consent prior to participation.

2.2. Material and procedure

Bicycles were equipped with a GPS action camera (Contour +2™) according to the procedure described in [Westerhuis and De Waard \(2016\)](#) and [Westerhuis, Jelijs, Fürmaier, and De Waard \(2017\)](#). The camera was mounted on the handlebars of the participant's bicycle and directed forward with the front wheel visible. A measurement aiding tool was filmed before each bicycle trip to allow for measurement of lateral position. Recordings took place with a resolution of 1280×720 pixels at 30 frames per second.

Upon arrival, participants first were informed about the study and completed a questionnaire on bicycle use and cycling experience. In the time they filled out the questionnaire the GPS camera was attached to their bicycle and was calibrated.

Participants were asked to cycle a fixed 4.2-kilometre route through the city of Groningen ([Fig. 1](#)). They were instructed to cycle as they would normally do. During this ride they were followed by a researcher on a bicycle that was also equipped with a GPS camera. The researcher gave directions through a walkie-talkie that both the researcher and the participant wore around their necks. Participants were not required to operate the walkie-talkie. In [Fig. 1](#) three locations of interest are indicated, also shown in [Fig. 2](#). The first is an “all-green” intersection. On these intersections cyclists from all directions get a green light, and are unbundled from motorised traffic. Cyclists need to resolve who goes first in interaction with each other as no priority-rules apply. It is a situation that is unknown abroad. The second is a control section, a one-way cycle path (separate from the main road), the third a roundabout. The roundabout involved interaction with motorised traffic, even though cyclists had right-of-way. Both Green-for-all intersections and roundabouts can be experienced as high task demand situations. Older cyclists, for example, mention these situations as being difficult and they preferably avoid them ([Engbers, 2019](#)). However, as the experiment was carried out outside rush hours, traffic is low and traffic complexity was in this way limited. After passing each of these three locations, participants were asked to stop on the pavement and give a rating on how mentally effortful they had experienced the just passed situation. For this the Rating Scale Mental Effort (RSME, [Zijlstra, 1993](#)) was used. This scale has a range from 0 to 150, with 2 = “absolutely no effort”, and 112 = “extreme effort”. Additionally, participants were asked to rate how safe they had felt during the just passed situation on a scale from 1, “not at all safe”, to 10, “completely safe”. Ratings were written down by the researcher. In total it took between 15 and 20 minutes to complete the ride. At the end of the experiment, all participants received a debriefing form, which informed them about the purpose of the study.

2.3. Behavioural measures and observations

Cycling behaviour was assessed by measuring speed (in km/h, based on GPS data), lateral position (distance to the kerb, in centimetres, based on video images), and by calculating displacement variability (SD of the Lateral Position, SD LP). Measurements were completed on the control section ([Fig. 1](#)) where participants cycled on a bicycle path with little traffic and no parked cars on the side. Per participant over a period of 90 s, 20 lateral position samples were scored by measuring the distance of the front wheel to the kerb using a digital ruler (JRuler Pro™ 3.1 for Windows™).

Behaviour of the participants was also observed by the researchers. Violations and mistakes made were scored in two categories: potentially dangerous (e.g., red light infringement) and minor (e.g., non-optimal location to stop for an intersection, but without disrupting traffic flow or endangering safety). The whole ride was analysed by looking at the footage made with the camera mounted on the researcher's following bicycle.

2.4. Statistical analysis

Statistical analyses were performed with SPSS 25.0.0.1 for Windows. Alpha was set at 0.05, and for the interpretation of effect sizes the classification proposed by [Cohen \(1988\)](#), with effect sizes categorised as small ($0.0099 \leq \eta_p^2 < 0.0588$), medium ($0.0588 \leq \eta_p^2 < 0.1379$), and large ($\eta_p^2 \geq 0.1379$). The participant's nationality served as the independent variable, with

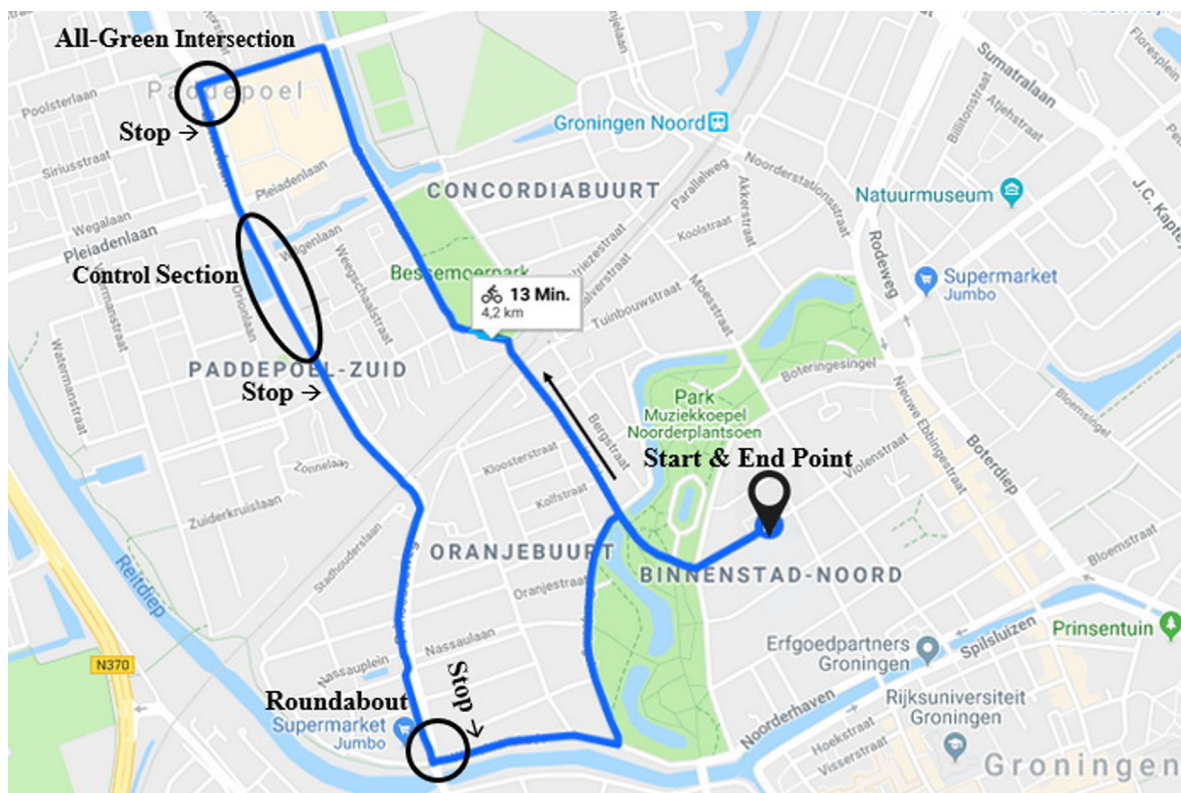


Fig. 1. Cycling route through Groningen, the Netherlands (image “Google Maps”, 2019). Three locations of interest are indicated: an all-green intersection in the North, a control section on a one-way bicycle path, and a roundabout (see also Fig. 2). After passing these locations participants were asked to stop on the pavement and give a rating of invested mental effort and perceived safety. (see Section 2.2).

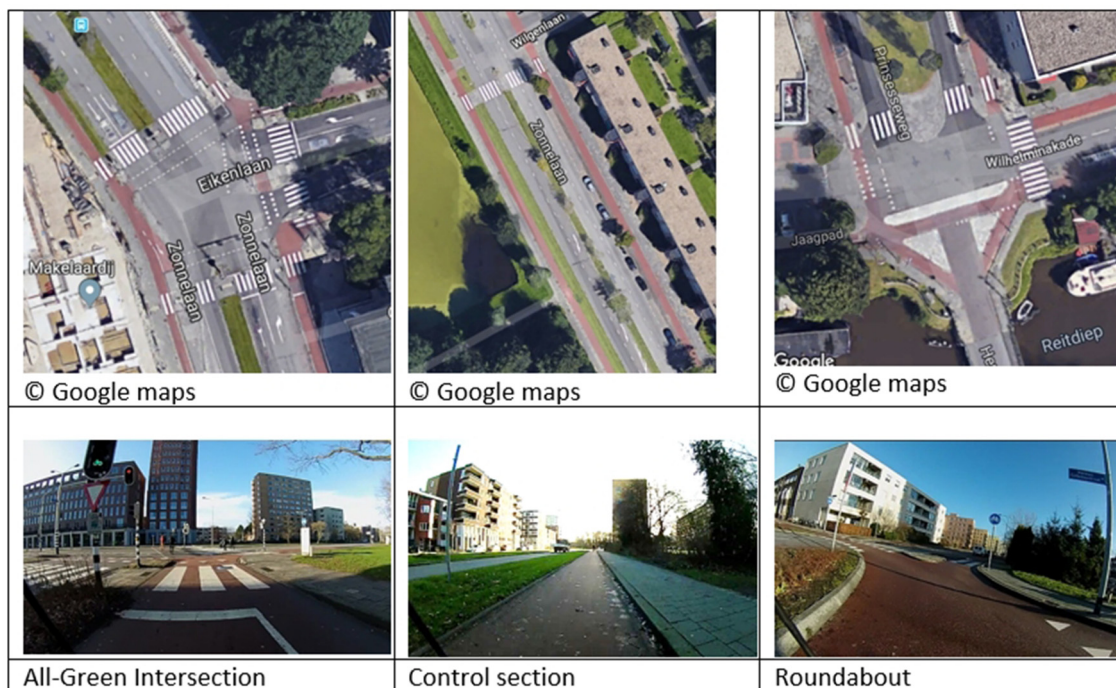


Fig. 2. Helicopter view (top images) and cyclist view of the three locations of interest.

nationality either Dutch or non-Dutch. A one-way ANOVA was conducted to test whether there were differences on speed, lateral position (LP), and standard deviation of lateral position (SD LP) between the two independent groups. For the analysis of mental effort and safety ratings, a mixed ANOVA was conducted testing for differences between the two groups on the three locations.

3. Results

Due to a sudden change in weather conditions, two participants, one in each group, were not able to complete the experimental ride. Additionally, for one participant in the non-Dutch group, recordings of camera (i.e. speed and lateral position) failed and for one participant in the Dutch group there were no GPS data available. Therefore, for the analysis 34 participants (15 Dutch, 19 non-Dutch) were included for the measures of average lateral position and lateral displacement variability and 33 (14 Dutch, 19 non-Dutch) for speed.

3.1. Participants

Dutch participants all had the Dutch nationality and indicated that they had been cycling regularly before moving to Groningen. The group of non-Dutch participants had a predominantly European background; 57% was German (12 participants), two were American, five were European (Slovak, Swedish, Ukrainian, Lithuanian, and Norwegian), one was Chinese and one was Indian. Of the non-Dutch students, 76% indicated to have cycled regularly before moving to the Netherlands.

3.2. Behavioural measures

3.2.1. Speed

No differences in cycling speed were found between the two groups, Dutch participants cycled on average 16.5 km/h (SD 2.0), non-Dutch participants cycled 16.2 km/h (SD 2.2) ($F(1, 31) = 0.165$, $p = .69$, $\eta_p^2 = 0.005$).

3.2.2. Lateral position and displacement variability

This difference in average position on the cycle path between the two groups is significant only at 10% level ($F(1, 31) = 3.77$, $p = .061$, $\eta_p^2 = 0.108$), with non-Dutch students keeping less distance to the kerb than Dutch students: 64 cm (SD 7.2) versus 71 cm (SD 13.3). Average displacement variability was similar for both groups: for Dutch students 13.2 cm (SD 3.2), for non-Dutch students 14.6 cm (SD 4.3), ($F(1, 31) = 0.973$, $p = .331$, $\eta_p^2 = 0.030$). Remarkable is, however, the large variability in this measure within the group non-Dutch participants (Fig. 3).

3.2.3. Subjective ratings of effort and safety

At three locations, the green-for-all intersection, the control section, and the roundabout, participants were asked to rate how effortful passing that location had been for them (Fig. 4, scale: RSME, range low-high: 0–150), and how they perceived safety (low-high: 1–10).

No main effect of group was found ($F(1,33) = 1.525$, $p = 0.226$, $\eta_p^2 = 0.044$). However, ratings over locations differed ($F(2,66) = 14.928$, $p < 0.001$, $\eta_p^2 = 0.311$). Pairwise comparisons showed that the straight control section was rated as significantly less mentally effortful than both the all-green intersection ($p < .001$) and the roundabout ($p < .001$). There was no interaction effect between group and location ($F(2,66) = 1.484$, $p = 0.234$, $\eta_p^2 = 0.043$).

Similar effects were found for safety ratings (scale 1–10, 1 = very unsafe, 10 = very safe). No group differences were found ($F(1, 33) = 1.290$, $p = 0.264$, $\eta_p^2 = 0.038$), only differences between locations ($F(2, 66) = 11.077$, $p < 0.001$, $\eta_p^2 = 0.251$), with the control section being rated as safest (average 9.1, SD 1.12) and the all-green intersection (average 8.2, SD 1.27) and roundabout (average 8.3, SD 1.06) as less safe. All average ratings were thus above 8 which can be labelled “safe”.

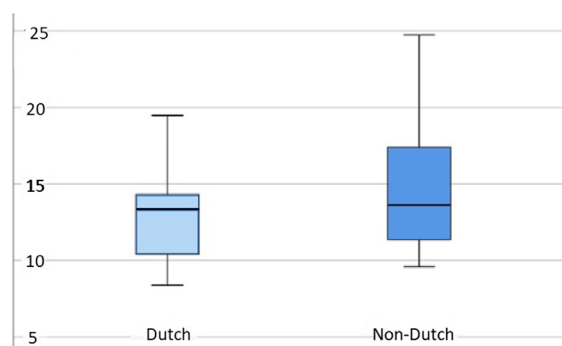


Fig. 3. Box plot of the standard deviation of lateral displacement in centimetres per group. Whiskers reflect minimum and maximum values.

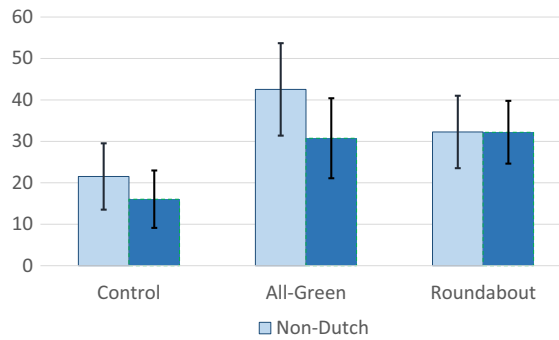


Fig. 4. RSME ratings of mental effort (0–150). A rating of 27 coincides with “a little effort”, 38 “some effort”. Error bars denote the 95% confidence interval.

3.2.4. Violations and mistakes

While 50% ($N = 7$) of the Dutch participants made at least one mistake during the study, 42.1% ($N = 8$) of the non-Dutch students did. However, the severity of the mistakes varied between groups. As indicated earlier, mistakes considered to be not severe were non-violations of traffic rules or situations which never or rarely interrupted traffic flow, e.g. standing too much to the right when intending to turn left. Severe mistakes or violations on the other hand were situations which could interrupt traffic flow and could precede an incident or even accident. Such mistakes or violations included red light infringement, using the car lane instead of bicycle lane while waiting for a traffic light, not giving right of way, or not following the official route on the roundabout. Dutch students made more mistakes that could be considered minor while international students more frequently made severe mistakes, and often more than one per participant (Table 1).

3.2.5. Questionnaire

Time passed from the beginning of the academic year to the time of the experiment was between three and six months. This means that some time had passed since the non-Dutch students had moved to Groningen. In the questionnaire that was completed before the outdoor part of the experiment started, it was explicitly asked whether opinion and feelings with regard to cycling had changed in that time. Results are in Table 2.

Participants were also asked to indicate how many near crashes and actual crashes they had had during the last two months before taking part in the study. A near accident was defined as a situation in which at least one traffic participant had to brake considerably or evade in order to avoid an accident. One participant was excluded due to an unlikely high number of near crashes (25)¹. The Dutch average was one (SD 1.134) near-accident during the past two months while the non-Dutch group's average was higher with 2.2 (SD 2.2) ($F(1, 34) = 3.60$, $p = .066$, $\eta_p^2 = 0.096$). For the actual crashes; the Dutch students had had an average of 0.133 accident (SD 0.35) while the non-Dutch students on average had had 0.523 crashes (SD 0.60) ($F(1, 34) = 5.06$, $p = .031$, $\eta_p^2 = 0.129$).

4. Discussion and conclusion

In this study the cycling behaviour of non-Dutch students that had arrived in the Netherlands between three and six months earlier was compared with Dutch students' behaviour. Support for the first hypothesis that there is no difference in cycling performance was found, but only for the control level (Michon, 1985), where performance between the two groups was very similar. No statistically significant differences in average speed or lane position were found between the groups, with the remark that variability in average position on the cycle path was larger between participants in the group non-Dutch students and that this group on average cycled seven centimetres closer to the kerb. With regard to reported mental effort investment, the second hypothesis, also no difference between the two groups was found. However, performance on the manoeuvre level did differ, it was observed that non-Dutch students violated traffic rules more often and made more serious errors than Dutch participants. Non-Dutch participants infringed red lights and cycled against traffic in the opposite way. This also happened on the roundabout, which has been noted to be a location where cyclists are in particular at risk to be involved in serious injury crashes (Polders, Daniels, Casters, & Brijs, 2015). Errors on this level can possibly be related to the higher number of actual crashes that the group non-Dutch students report over the previous two months, on average 0.52 opposed to 0.13 for Dutch participants. It is remarkable that the non-Dutch participants made these errors during the study, they knew they were observed by a researcher who followed them on a bicycle. This behaviour can also be taken as an indication that the instructions, “to cycle as they normally would”, were well followed. At the same time, it has to be

¹ The exclusion criterion was based on the calculation to define the upper bound (interquartile range + 1.5 x third quartile). The outlier scored above this upper bound and therefore was excluded from further analyses.

Table 1

Mistakes and violations (count per group) made during the ride based on observations of the video material of the following bicycle (N = 37).

		Dutch (count)	Non-Dutch (count)
Severe	Red light infringement	0	2
	Going the wrong direction (against traffic)	0	2
	Not stopping for pedestrian at zebra crossing	0	1
	Disregarding right of way	0	2
Less severe	Standing in wrong turning lane	6	1
	Leaving cycle lane	1	3
	Leaving cycle path	1	0
	Cycling on pavement	0	2
	Total	8	13

Table 2

Answers to the question “Compared to when I started my studies in Groningen, now, at this time, I feel...” (non-Dutch students only, N = 21).

	Strongly agree	Agree	Neither	Disagree	Strongly disagree
Safer while cycling	19.0%	66.7%	14.3%	–	–
That I have more control over my bicycle	14.3%	52.4%	28.5%	4.8%	–
I take more risks	9.5%	66.7%	–	19%	4.8%
I know better what is expected of me as a cyclist	23.8%	57.1%	14.3%	4.8%	–
More at ease during cycling	33.3%	42.9%	9.5%	9.5%	4.8%
I am more aware what goes on around me	33.3%	52.4%	9.5%	4.8%	–

added that Dutch cyclists also violate traffic rules frequently (e.g., more than 25% have been observed to run red lights, Van der Meel, 2013), they just did not do this in this experiment.

There are some limitations to this study. To start with, the ethical committee demanded that the experiment should be carried out outside rush hours and only with people who were active cyclists. On the one hand this prevented participants from encountering complex busy situations during the experiment, situations that could be perceived as chaotic and elicit more errors. On the other hand, the participation of only active cyclists means that these people did not stop cycling after arrival. It does not reflect the early behaviour closely after arrival. Also, the non-Dutch participants almost all came from European countries and most came from nearby Germany. Only one cyclist from India and one from China participated. All participants had to cycle regularly, and then finding no differences on the control level (balancing, position on the road) is no surprise. Results do not give information about whether there are people who were deterred from cycling and stopped and had to seek another way of mobility. To study effects of all non-Dutch students, and also more acute effects, a test closely after arrival could be performed in a safe environment, such as a cycling simulator.

Perhaps in the first month after arrival cycling behaviour of non-Dutch students is still comparable to what has been found for tourist drivers (as opposed to new resident drivers, Yannis et al., 2007, Romano et al., 2013). The non-Dutch students that participated also stated that compared to when they started their studies in Groningen, they felt safer and took more risks and had more control over the bicycle. Still, in the two months that just passed, they were involved in more crashes, which could be related to not being familiar with the new environment, infrastructure, and regulations. This finding is congruent with differences found between experienced and inexperienced cyclists; experienced cyclists recognise hazards more often and more easily (Lehtonen, Havia, Kovanen, Leminen, & Saure, 2016). However, in the longer term, behaviour of non-Dutch cyclists at the manoeuvre level may well (further) improve, just as with new immigrant drivers. If this is correct it would mean that cyclists are in particular at risk during the first months after arrival.

In conclusion, non-Dutch students who continue to cycle cannot be distinguished from Dutch students on the basis of low, control level of cycling performance after three months. There are, however, indications that on the higher manoeuvre level non-Dutch cyclists make more errors. Errors on this level may put them at risk. If this is due to a lack of knowledge, then information about the most important rules of cycling in the Netherlands could be handed out upon arrival or cycling lessons could be offered. For this it is also important to find out whether non-Dutch students experience problems while cycling in the first weeks after arrival, and also whether there are individuals who stop cycling or for whom cycling remains difficult. The large variability in the standard deviation of lateral displacement in the group non-Dutch students indicates that this may be the case, i.e., there are individuals who do not master vehicle control after having spent several months in Groningen.

Declaration of Competing Interest

The authors declared that there is no conflict of interest.

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